

WHAT IS CLAIMED IS:

1 1. A hydraulic control system for a belt-drive continuously  
2 variable transmission (CVT) of a vehicle, the CVT including  
3 a belt, the hydraulic control system comprising:

4       an oil pump operative to produce an oil pressure and an  
5 oil flow amount which are supplied to the CVT;

6       a pressure regulator valve operative to regulate the oil  
7 pressure produced by the oil pump;

8       a belt lubricating oil supply passage for supplying oil  
9 to the belt on a downstream side of the pressure regulator  
10 valve;

11       engine operating condition detecting means for detecting  
12 an engine operating condition and generating a signal  
13 indicative of the engine operating condition detected; and

14       a controller for controlling the oil flow amount based  
15 on the signal, the controller being programmed to:

16       calculate a CVT input torque based on the signal;

17       calculate a required belt lubricating oil flow amount to  
18 be supplied to the belt on the basis of the signal and the  
19 CVT input torque;

20       determine a minimum speed of the oil pump based on the  
21 required belt lubricating oil flow amount; and

22       control the oil pump at the minimum speed.

1 2. The hydraulic control system as claimed in claim 1,  
2 wherein the engine operating condition detecting means  
3 comprises an oil temperature sensor operative to detect a  
4 temperature of the oil in the CVT and generate an oil  
5 temperature signal indicative of the oil temperature  
6 detected.

1 3. The hydraulic control system as claimed in claim 1,  
2 wherein the engine operating condition detecting means

3 comprises a throttle position sensor operative to detect a  
4 throttle opening degree and generate a throttle opening  
5 degree signal indicative of the throttle opening degree  
6 detected.

1 4. The hydraulic control system as claimed in claim 2,  
2 wherein the CVT includes a primary pulley, the hydraulic  
3 control system further comprising primary pulley speed  
4 detecting means for detecting rotational speed of the  
5 primary pulley and generating a primary pulley speed signal  
6 indicative of the rotational speed detected, the controller  
7 receiving the primary pulley speed signal, the controller  
8 being programmed to calculate the required belt lubricating  
9 oil flow amount based on at least one of the CVT input  
10 torque and the primary pulley speed signal when the oil  
11 temperature is not less than a predetermined value.

1 5. The hydraulic control system as claimed in claim 4,  
2 wherein the CVT includes a secondary pulley, the hydraulic  
3 control system further comprising secondary pulley speed  
4 detecting means for detecting rotational speed of the  
5 secondary pulley and generating a secondary pulley speed  
6 signal indicative of the rotational speed detected, the  
7 controller receiving the secondary pulley speed signal, the  
8 controller being programmed to:

9 calculate a pulley speed ratio between the rotational  
10 speed of the primary pulley and the rotational speed of the  
11 secondary pulley; and

12 calculate the required belt lubricating oil flow amount  
13 based on at least one of the CVT input torque, the primary  
14 pulley speed signal and the pulley speed ratio when the oil  
15 temperature is not less than a predetermined value.

1   6. The hydraulic control system as claimed in claim 2,  
2   further comprising an oil cooler disposed on a downstream  
3   side of the pressure regulator valve, a lubricating oil  
4   supply path for supplying the oil to lubrication parts in  
5   the CVT, the lubricating oil supply path being disposed on a  
6   downstream side of the oil cooler and including the belt  
7   lubricating oil supply passage, and line pressure detecting  
8   means for detecting a line pressure between the oil pump and  
9   the pressure regulator valve and generating a line pressure  
10   signal indicative of the line pressure detected, the  
11   controller receiving the line pressure signal, the  
12   controller being programmed to:

13       calculate a required cooler oil flow amount to be  
14   supplied to the oil cooler from the required belt  
15   lubricating oil flow amount on the basis of a predetermined  
16   oil distribution ratio of an oil flow amount to be supplied  
17   to the belt lubricating oil supply passage to an oil flow  
18   amount to be supplied to the lubricating oil supply path;

19       calculate a cooler input pressure to be supplied to the  
20   oil cooler on the basis of the required cooler oil flow  
21   amount; and

22       determine the minimum speed of the oil pump based on the  
23   cooler input pressure, the oil temperature signal and the  
24   line pressure signal.

1   7. The hydraulic control system as claimed in claim 5,  
2   wherein the CVT has a manual transmission mode allowing to  
3   manually change the pulley speed ratio, the hydraulic  
4   control system further comprising transmission mode  
5   detecting means for detecting that the CVT is in the manual  
6   transmission mode and generating a manual mode signal  
7   indicative of the CVT in the manual transmission mode, the

8 controller being programmed, in response to the manual mode  
9 signal, to clear the minimum speed of the oil pump.

1 8. The hydraulic control system as claimed in claim 5,  
2 wherein the CVT has a manual transmission mode allowing to  
3 manually change the pulley speed ratio and an automatic  
4 transmission mode allowing to automatically change the  
5 pulley speed ratio, the hydraulic control system further  
6 comprising transmission mode detecting means for detecting  
7 whether the CVT is in the manual transmission mode or in the  
8 automatic transmission mode and generating a manual mode  
9 signal indicative of the CVT in the manual transmission mode  
10 and an automatic mode signal indicative of the CVT in the  
11 automatic transmission mode, the controller being programmed,  
12 in response to the manual mode signal, to set the minimum  
13 speed of the oil pump larger than in the automatic  
14 transmission mode.

1 9. The hydraulic control system as claimed in claim 1,  
2 wherein the vehicle includes an anti-lock brake system (ABS)  
3 actuator operative to control a braking pressure, an ABS  
4 control unit for generating an ABS control signal to the ABS  
5 actuator, and an ABS control sensor operative to detect the  
6 ABS control signal and generate an ABS control ON signal  
7 indicative of ABS control being conducted, the controller  
8 being programmed, in response to the ABS control ON signal,  
9 to clear the minimum speed of the oil pump.

1 10. The hydraulic control system as claimed in claim 6,  
2 wherein the belt lubricating oil supply passage comprises a  
3 belt lubricating nozzle for injecting the oil to the belt,  
4 the lubricating oil supply path comprising a gear

5 lubricating nozzle for injecting the oil to a differential  
6 gear.

1 11. A method for controlling a belt-drive continuously  
2 variable transmission (CVT) of a vehicle, the CVT including  
3 a belt, the vehicle including an oil pump operative to  
4 produce an oil pressure and an oil flow amount which are  
5 supplied to the CVT, a pressure regulator valve operative to  
6 regulate the oil pressure produced by the oil pump, and a  
7 belt lubricating oil supply passage for supplying oil to the  
8 belt on a downstream side of the pressure regulator valve,  
9 the method comprising:

10 generating an engine operating condition signal  
11 indicative of an engine operating condition;

12 calculating a CVT input torque based on the engine  
13 operating condition signal;

14 calculating a required belt lubricating oil flow amount  
15 to be supplied to the belt on the basis of the engine  
16 operating condition signal and the CVT input torque;

17 determining a minimum speed of the oil pump based on the  
18 required belt lubricating oil flow amount; and

19 controlling the oil pump at the minimum speed.

1 12. The method as claimed in claim 11, wherein the engine  
2 operating condition signal comprises an oil temperature  
3 signal indicative of a temperature of the oil in the CVT,  
4 the required belt lubricating oil flow amount being  
5 calculated based on the oil temperature signal.

1 13. The method as claimed in claim 11, wherein the engine  
2 operating condition signal comprises a throttle opening  
3 degree signal, the CVT input torque being calculated based  
4 on the throttle opening degree signal.

1 14. The method as claimed in claim 12, wherein the CVT  
2 includes a primary pulley, the method further comprising  
3 generating a primary pulley speed signal indicative of a  
4 rotational speed of the primary pulley, and calculating the  
5 required belt lubricating oil flow amount based on at least  
6 one of the CVT input torque and the primary pulley speed  
7 signal when the oil temperature is not less than a  
8 predetermined value.

1 15. The method as claimed in claim 14, wherein the CVT  
2 includes a secondary pulley, the method further comprising:  
3       generating a secondary pulley speed signal indicative of  
4 a rotational speed of the secondary pulley;  
5       calculating a pulley speed ratio between the rotational  
6 speed of the primary pulley and the rotational speed of the  
7 secondary pulley; and  
8       calculating the required belt lubricating oil flow  
9 amount based on at least one of the CVT input torque, the  
10 primary pulley speed signal and the pulley speed ratio when  
11 the oil temperature is not less than a predetermined value.

1 16. The method as claimed in claim 12, wherein the vehicle  
2 includes an oil cooler disposed on the downstream side of  
3 the pressure regulator valve and a lubricating oil supply  
4 path for supplying the oil to lubrication parts in the CVT,  
5 the lubricating oil supply path being disposed on a  
6 downstream side of the oil cooler and including the belt  
7 lubricating oil supply passage, the method further  
8 comprising:

9       generating a line pressure signal indicative of a line  
10 pressure between the oil pump and the pressure regulator  
11 valve;

12 calculating a required cooler oil flow amount to be  
13 supplied to the oil cooler from the required belt  
14 lubricating oil flow amount on the basis of a predetermined  
15 oil distribution ratio of an oil flow amount to be supplied  
16 to the belt lubricating oil supply passage to an oil flow  
17 amount to be supplied to the lubricating oil supply path;  
18 calculating a cooler input pressure to be supplied to  
19 the oil cooler on the basis of the required cooler oil flow  
20 amount; and

21 determining the minimum speed of the oil pump based on  
22 the cooler input pressure, the oil temperature signal and  
23 the line pressure signal.

1 17. The method as claimed in claim 15, wherein the CVT has  
2 a manual transmission mode allowing to manually change the  
3 pulley speed ratio, the method further comprising:

4 generating a manual mode signal indicative of the CVT in  
5 the manual transmission mode; and

6 clearing, in response to the manual mode signal, the  
7 minimum speed of the oil pump.

1 18. The method as claimed in claim 15, wherein the CVT has  
2 a manual transmission mode allowing to manually change the  
3 pulley speed ratio and an automatic transmission mode  
4 allowing to automatically change the pulley speed ratio, the  
5 method further comprising:

6 generating a manual mode signal indicative of the CVT in  
7 the manual transmission mode and an automatic mode signal  
8 indicative of the CVT in the automatic transmission mode;  
9 and

10 setting, in response to the manual mode signal, the  
11 minimum speed of the oil pump larger than in the automatic  
12 transmission mode.

1 19. The method as claimed in claim 11, wherein the vehicle  
2 includes an anti-lock brake system (ABS) actuator operative  
3 to control a braking pressure and an ABS control unit for  
4 generating an ABS control signal to the ABS actuator, the  
5 method further comprising:

6 generating an ABS control ON signal indicative of ABS  
7 control being conducted; and

8 in response to the ABS control ON signal, clearing the  
9 minimum speed of the oil pump.

1 20. The method as claimed in claim 16, wherein the belt  
2 lubricating oil supply passage comprises a belt lubricating  
3 nozzle for injecting the oil to the belt, the lubricating  
4 oil supply path comprising a gear lubricating nozzle for  
5 injecting the oil to a differential gear.